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ANNUAL ADDRESS

OF

CHAS. P. DALY, LL. D., PRESIDENT OF THE SOCIETY.

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ON THE HISTORY OF PHYSICAL GEOGRAPHY.

I have made the subject of my annual address this year the History of Physical Geography. I have selected this subject because it is one that, so far as I know, has not yet been generally inquired into, and because the information that is requisite to a knowledge of it is not to be found in the ordinary works of reference or encyclopædias, but has to be gathered from many sources and over a wide field of inquiry. Before entering upon its history it will be, perhaps, appropriate that I should first state what the Science of Physical Geography is.

Alexander Von Humboldt in his last and greatest work, "Cosmos," divides the subject of which he treats into two parts: 1st, the physical system of the Universe, and 2d, the physical system of the Earth, the latter being, in a general way, what is now understood by the Science of Physical Geography.

It embraces the form and movements of the earth, the

configuration of its surface, the aërial covering or atmosphere that surrounds it, the relative distribution of land and water, the currents of the air and of the sea ; the distribution of heat, the magnetic influence that affects the earth, and many other details of a physical nature relating to it, which were formerly embraced under the general head of Geography, but which are now taken from it and arranged into a distinct and separate science.\*

Humboldt's idea of science is mind applied to nature. "Science," he says, "begins for man the moment that his mind lays hold of matter, and he endeavors to subject the mass of material that has accumulated into rational combinations."

This is Sir John Herschel's idea of the Science of Physical Geography. "It takes," he says, "the heap of particulars that is stored up by descriptive geography, to present them as a harmonious whole, by showing that they are all bound up together by mutual relations or inter-agencies and are all subordinate to a great scheme of providential arrangement."†

The history of this science is a history of how man acquired his knowledge of the true nature of the earth and of the physical laws or phenomena connected with it. It is a history that naturally begins with the first impressions that he had of the earth and its phenomena, which

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\*Humboldt included in it the geographical distribution of plants and animals, but W. E. Cooley in his recent treatise omits this as more appropriately belonging to the sciences of Botany and Zoology. (*Cooley's Physical Geography, Preface vii. London, 1876.*)

†Cooley defines it more strictly as that department of science which embraces the course of physics reigning on the earth's surface, over land, sea and air, and of which, as it depends to some extent on the features of that surface, Geography is a function. (*Cooley's Physical Geography, Preface.*)

carries us back to a very primitive age, and suggests at the outset what knowledge we can possibly have of man's impressions respecting the earth, at a period so remote.

Niebuhr says, in his Historical Lectures, that if we exclude the history of the earth and confine ourselves to the history of mankind, we can go back only to those times, the traditions of which have come down to us, as the history of nations and of periods, before the discovery of the art of writing, is buried in impenetrable darkness. At the time, he says, when our traditions begin, we find the earth inhabited by a number of different races, distinguished from each other by their manners and their customs, as they are now, and that the further we go back the more we find that the languages were distinct and the nations foreign to each other; and he concludes with the remark that whether these nations were originally of different origin, or whether their original identity was gradually changed in form and in language, we cannot arrive at any certain knowledge without a distinct revelation from God, and that upon these points the Book of Genesis cannot be considered as a revelation.

It is now about sixty years since these words were uttered by one of the most acute and learned historical critics that ever lived, and yet within that comparatively short time prodigious strides have been made towards a knowledge of that period, which to Niebuhr was one of impenetrable darkness.

The studies in comparative philology, or to speak more plainly, of different languages, have disclosed that many nations, that for centuries have been separately

distributed over the globe and apparently wholly distinct from each other, are in fact connected together by the common tie of language, and are all descended from a single stock or people who spoke one tongue.

The discoveries that have since been made in Egypt, the oldest civilization so far as our present knowledge extends, as well as upon the sites of the Chaldean, Babylonian, Assyrian, Arabian and other ancient civilizations, such as temples, tombs, dwellings, inscriptions, engraved gems, cylindrical tablets, records and documents in clay, works of art and pictorial representations of customs, amusements and domestic life, as well as of the industrial arts, which have been brought together and studied under what has now become a new science, that of comparative archæology, have shed a flood of light on ancient civilizations that were wholly unknown half a century ago, and another science, that of comparative mythology, has revealed man's beliefs respecting the earth and many other things, up to a very primitive period.

Not only has all this been acquired, but within the same time researches have been carried on and discoveries made in respect to primitive man that disclose very plainly what was his original state in every part of the globe.

There was formerly a widespread and persistent belief which, as I shall presently show, was of Egyptian origin, that there was once what was called "A Golden Age;" in which everything that was necessary to man's existence was produced without his instrumentality; an age of innocence and of happiness, of abundance without toil, of ideal justice, of peace and equality, during

which a perpetual Spring made the earth an abode of delight.\*

This belief had a great fascination for the classic poets, and as its long continuance shows, for mankind generally ; for it was pleasant to think of a time when there was no evil, but everything was virtuous and good.

The labors of the ethnologist and the anthropologist, however, prove that there never was such an age. Their researches and discoveries show that so far as the remains of man, or of anything pertaining to him have been found, his early condition was everywhere the same, that his first state was one in which he depended for subsistence upon fishing, the chase, and the wild fruits of the earth ; the state of a hunter or fisher, as appears in the fact that in the earliest deposits in which his remains have been discovered, the rude implements of bone or of stone, with which he fished, hunted or killed the wild animals upon which he subsisted, are found with him ; a condition that has not yet entirely passed away, but one in which he is still found, in Australia and in other parts of the earth.

His next and more advanced stage was, in those countries where the climate allowed it, that of the possessor of flocks and herds, moving about from place to place as pasturage was afforded, a state still existing, and to a considerable extent, in certain parts of Asia : and the next was when he settled down in fixed abodes as an agriculturist ; when men congregating together began the building of towns, the founding of cities and the formation of nations.

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\* La Rousse, *Le Grand Dictionnaire Universel du XIX Siècle*, ART. *Âges*.

That, before this, man lived everywhere in what has been called a stone age, is attested by the fact that on the sites of the most ancient civilizations his rude stone implements have been found, such as stone axes, spear-heads, flint arrow-heads, etc. In Egypt, along the banks of the Nile, and for a considerable distance over Northern Africa, these rude stone implements have been discovered, attesting that before this early civilization began the men who used these rude implements dwelt there.

What is especially striking in the recent researches of the ethnologists, is the wide distribution of these remains throughout the earth, and the great length of time that man must have been an inhabitant upon it. "In every part of the globe," says the Marquis de Nadaillac, one of the most recent investigators of the subject, "in all latitudes, under all climates, the chipped flints (*les silex*), whether they are simply cut, or polished by persevering labor, present an analogy which strikes the most superficial observer." \*

This early distribution of savage man all over the globe is the more remarkable when it is considered that the early stages of civilization were not favorable to the growth of geographical knowledge. When men who had formerly wandered about as hunters and fishers settled down to the cultivation of the earth as a more certain means of subsistence, what they wanted was to be let alone. They had no desire to know anything of the countries and the people about them, and what they desired more especially was that nothing should be

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\* *Moeurs et Monuments des Peuples Préhistoriques*, par le Marquis de Nadaillac, Paris, 1880.



known about them, as these outside wandering and warlike tribes, that were ever in quest of food, might suddenly descend upon them and sweep away all the fruits of their industry. In fact, this goes on at the present day in certain parts of north-eastern Asia, where the hill tribes, in seasons when game or other means of subsistence is scarce, come down upon the peaceful agricultural dwellers of the plains and carry off their cattle and everything that they have stored up as food. Even the Indians in our own country, when they have settled down as agriculturists upon the lands allotted to them by the government, have a hard struggle ; not from the inroads of warlike tribes in their vicinity, but from the friendly nomads, who, in the winter, when food is scarce, frequently come and claim the right of hospitality in such numbers that everything that the settled Indians have laid up for themselves is consumed. In fact, what man wanted in the earliest stages of civilization was isolation and security, and when we consider this we may form some conception of how difficult was the growth and development of early civilizations.

During the last half century the question has also been extensively discussed, whether man, in all the varieties in which we find him now, is the product of a single race, or whether there was originally a diversity of races. The difficulty in this question is, that men have now become so intermixed by the intercommunication that has been going on for a great length of time, that the traces of an original distinction, if it ever existed, must now be nearly obliterated, and all, I think, that can be said respecting this investigation is, that nothing has been absolutely proved.

Another marked feature in this general inquiry, has been the rise during the last thirty years, or perhaps I should say the revival, of what has been called the theory of Evolution, and, as growing out of it, the inquiry known as the Origin of Species, and the Descent of Man, commonly called Darwinism.

As the science of geology has proved that the order in which plants and animals have appeared upon the earth has been from simple to more complex organizations, or, as the geological divisions show, the law of progress is from lower to higher forms, a fact which I apprehend is now generally accepted, Darwin and his followers have undertaken to show that the way in which this takes place is that there is a tendency in all species, whether of plants or animals, to branch off into varieties, most of which perish, while some survive, to transmit their peculiar differences or varieties to their offspring, so that a new species is thereby created, which in time becomes permanent; and that this has been going on for long periods of time, and will account for all the varieties that now exist, whether in plants, animals, or in the human species. There is, these writers say, constantly going on a struggle for existence, in which the capable survive and the weaker perish; which Darwin expresses by the term "natural selection," and Herbert Spencer calls "the survival of the fittest." And that this has gone on until it has culminated in man, the highest and most perfect of organisms.

I simply state what this theory is as I understand it, without undertaking to discuss it. In such an inquiry as I am making into the early history of man, his relations to the physical phenomena by which he was sur-

rounded, and his early impressions respecting it, I could not well pass over an investigation to which so many scientific men have given their attention, and which has been so earnestly discussed by those who believe in it and by those who do not.

It is sufficient to say that this theory stops with the assumption that all plants and animals came from primordial germs. It does not undertake to explain how these primordial germs came into existence, or how, or why the liquid substance, that is found in the cells of the lowest organisms, is endowed with motion and is the source of life ; so that life, except as a direct act of the Creator, is as much a mystery as ever, a result warranting the remark of Dr. Scoffern that while Science removes mysteries, it, in doing so, opens up other mysteries.

This theory, I should further state, ignores a spiritual nature in man. At least Darwin had no belief in it, believing only in the natural operation of forces, although W. R. Wallace, the co-originator of the theory, as I gather from a recent notice of his last work, does believe in it, and seeks to harmonize it with his theory.

Edmund Burke pithily said that man was a "religious animal," and certainly all knowledge of him in the past warants the general conclusion that some form of religious belief is a necessary aliment of his nature, and that he will be slow to accept any theory in respect to his origin, or his nature, that does not admit this.

There is another matter in which our knowledge has been greatly enlarged since the time of Niebuhr : it is in respect to the earth itself. For this we are indebted

to the geologists, and I cannot give it more appropriately than in the recent language of one of our most eminent American geologists, Professor Joseph Le Conte. "There was a time," says Professor Le Conte, "not many decades ago, when all things, the origin of which transcends our ordinary experience, were supposed to have originated suddenly and without natural process ; there was a time when mountains were supposed to have been made at once, with all their wonderful diversified forms, their beetling cliffs, their thundering waterfalls, their gentle slopes and smiling valleys, as we find them. But now we know that they have become so only through a very gradual process, and that they are still changing. There was a time when continents and seas, gulfs, bays and rivers, were supposed to have originated at once, substantially as we see them. Now we know that they have been changing through all geological time, and are still changing. There was a time when rocks and soils were supposed to have been always rocks and soils—when soils were regarded as an original clothing, made on purpose to hide the nakedness of the new-born earth. Now we know that rocks rot down to soils, that soils are carried down and deposited as sediments and that sediments are consolidated into rocks ; the same materials being worked over and over again, passing through all these stages many times in the history of the earth ; for there was a time when it was thought that the earth, with substantially its present form, configuration and climate, was made at once, out of hand, as a fit habitation for man and animals. Now we know that it has been changing, preparing, becoming what it is, by a slow pro-

cess, through a lapse of time so vast, that the mind sinks exhausted in the attempt to grasp it."

This suggestion, of the great changes that the earth has undergone, brings us to the period when its surface was brought into a condition more nearly resembling what it is now, and which is the one where the science of geology may be said generally to end, and that of physical geography to begin. This is the time of the deluge, the Chaldean record of which is found in the Book of Genesis. Over various parts of the globe traditions exist of a deluge. Catlin states that among 120 tribes of Indians that he visited in North and South America, there was not a tribe that did not have a tradition of a deluge. Xenophon mentions five deluges during certain supposed periods, and the order of succession in which they occurred, the fourth of which was called by the Greeks the Deucalion Deluge, which was believed to have continued for three months.\* The Chinese have a record of a great inundation 2300 B. C., which overflowed the principal rivers of China.† And among the Assyrian discoveries of George Smith was a tablet or clay memorial containing a detailed account of a deluge substantially the same as the one narrated in Genesis.‡

But the occurrence of a great physical event of this kind does not depend alone upon these traditions. A geological examination of that large part of Russia known as the Steppes, shows from the configuration of the surface and the marine deposits throughout it, that the whole of this great area was once the bottom of a

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\* *L'Océan Ancien*, p. 41. † Catlin's *Letters*, vol. 1., p. 181. ‡ Howorth, *The Mammoth and the Deluge*, p. 446.

shallow sea, which, in the opinion of the traveller Tournefort, extended as far as the northern part of the Caucasus and there formed two vast gulfs, one of which was the Caspian Sea and the other the Euxine or Black Sea. Moreau de Jonnes, in a work "*L'Océan Ancien*," an author of extensive learning and great acuteness, maintains that this is the ocean of Homer, who did not, he insists, refer to the Atlantic, which, in Homer's time, was unknown beyond the Straits of Gibraltar. This author, de Jonnes, in view of the marine deposits that are spread over the whole of this region of the steppes, and other facts, such as that certain portions of the northern coasts of Europe are now rising, thinks that the comparatively flat bed of this ancient ocean was gradually raised, until it reached a certain point of elevation, when the whole of its vast sheet of water, extending from the mountains of Thrace to the Caucasus, was precipitated upon the plains of northern Asia, in an inundation so sudden and so widespread, that it swept everything before it, involving an enormous destruction of animals and human life; and that this great physical event left that part of northern Asia, which had theretofore supplied these animals with food, the sterile waste that it is now, and greatly changed the configuration of the surface of Asia, from the Sea of Aral to the Straits of the Bosphorus.

Mr. H. H. Howorth, in a very recent work, *The Mammoth and the Flood*, has brought together not only the many legends of different people in various parts of the earth, but a great array of facts from the explorations of travellers and the labors of archæologists and palæontologists, which, to quote his words, "Points unmistakably

to a widespread catastrophe, involving a flood upon a great scale." He shows that, before this event, the climate of northern Siberia was temperate and equable, where the mammoth existed in such prodigious numbers that the traffic in the ivory left by its remains has now been going on for more than a century ; and that these animals perished by some great catastrophe operating simultaneously over a wide area is proved, he thinks, because the condition in which their remains are discovered does not indicate an ordinary death, as they are tumbled, tossed, and heaped up together in large mounds, frequently upon the tops of hills, showing that the catastrophe in which they perished was such as would be produced by the onward movement of tumultuous waters in some great inundation or flood.\*

The Duke of Argyll, with that careful consideration that marks the investigations of this distinguished man, thinks it highly probable that in comparatively recent times great changes occurred, altering the earth's surface over a large part of Europe, and with a rapidity that caused a great destruction of animal life† ; and facts gathered by American investigators indicate a like state of things and from a like cause in North America.

But it is to the period of the great Asiatic Deluge and what followed it that my inquiries more particularly relate, for although the earliest remains of man have been found in America, it was in Asia, so far as the present state of our knowledge indicates, that the earliest civilizations began ; that of Egypt in the valley of the Nile, and those of Chaldea, Babylonia and Assyria in the valleys of

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\* Howorth, *op. cit.* ch. xi.

† Address before the Edinburgh Geological Soc. in 1883.

the Euphrates and Tigris; and it is the conception, which the men who founded these civilizations and their successors had of the physical phenomena by which they were surrounded, to which my inquiry is especially directed.

That these early civilizations began with, and grew out of the pastoral state, appears in their religion and their most ancient symbols. Their earliest worship was associated with the animals that belong to that state, such as the bull, the cow, and domestic animals generally. The ox was adored at Memphis, the ram at Thebes. The crook of the shepherd and the barb of the cowherd were the royal emblems or symbols of the Pharaohs, and the horn of the bull encircles the mitre of the Assyrian kings.\* What the ideas of these early civilizations were of the earth and of physical forces generally, we have two means of knowing; first from the ideas which savages have who are now in the condition in which these early people were, and secondly, by a study of the mythology of these early civilizations.

The mythologies of ancient nations were long supposed to have been merely the invention of priests and of poets. The Italian poet Boccaccio, about 500 years ago, appears to have been the first to question this general impression. He devoted most of his time in the latter part of his life to an elaborate study of them, and came to the conclusion that they were allegories symbolizing moral truths, and he undertook to explain many of them from this point of view. Two hundred years later, Bacon took up these investigations, coming also to the conclusion that they were allegories, and he devoted a

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\* *L'Océan Ancien*, p. 50.



great deal of his time unprofitably to guess at their meaning. Here the inquiry ended until the beginning of the present century, when the scientific study of languages and of comparative grammar, with the important results that followed it, drew attention to these mythologies and an elaborate and careful study of them has revealed the fact that these myths are man's earliest impressions of many matters affecting him, and what is important for our subject, that, while they include many other things, they exhibit the progressive stages of his belief respecting the physical phenomena by which he was surrounded. They embodied and expressed the popular belief and were diminished, enlarged, readjusted or otherwise changed as these early people advanced in civilization, but amid the many changes which they underwent they always continued to express the popular belief. Out of them and based upon them, the priests constructed their theogonies or religious systems, but did not create the myths, nor did the poets, who merely embellished them and gave them a more poetical form.

A considerable portion of them are what are called Nature myths, which show what these early people's ideas were of the earth, of the heavens and of the causes which produced thunder, the lightning, the wind, the rain, the dew, the snow, the hail and the more violent forces of nature which they saw in the destructive sweep of the tornado, the belching forth of volcanic fires and the shock of the earthquake.

All this appears when we investigate the nature myths of these early nations; and as we follow up the myth through its many changes to its more archaic or first form, we find that the conceptions which these early

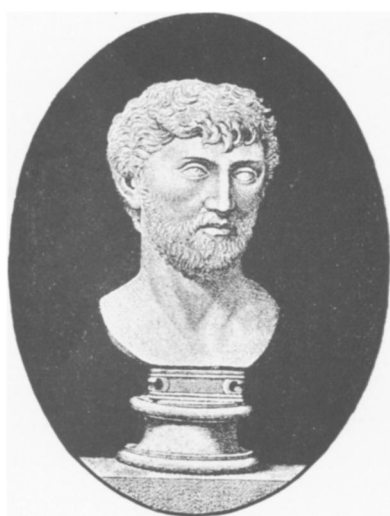
people had of physical phenomena, were substantially the same as those which we find among people living in a primitive state at the present day.

As a matter of general observation, savages give little attention to physical phenomena or the operations of nature, except where they are personally affected. Bruce, the traveller in Africa, frequently asked the negroes what became of the sun during the night, and whether we should see the same sun or a different one, in the morning ; but they uniformly regarded the question as childish, and had evidently never thought upon the subject.\* And when Dobrizhoffer, the Jesuit missionary, asked the Abipones, an equestrian tribe of South America, with whom he passed several years, whether the wonderful course of the stars and heavenly bodies had never raised in their minds the thought of an invisible being, who had made and guided them in their course, he received the very practical reply, that their ancestors had never cared to think about such matters, finding ample occupation for their thoughts in the providing of grass and water for their horses.

But where the operations of nature are destructive in their effects, it is otherwise. The impression then made is vivid. Men recognize the existence of a power by the injury it produces, and regard it as their enemy. We find this in our own period. The Payuguán Indians of North America rush out with fire-brands and with clenched fists against the wind that threatens to blow down their huts ; the Esthonians of Russia throw stones and knives against an approaching whirlwind ; the Kalmucks fire guns at the storm ; the Namaguas shoot poisoned arrows against

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\*Park's Travels, Vol. 1. p. 265, and Lubbock's Origin of Civilization, 5.



LUCRETIVS

it, and in the Aleutian Islands a whole village will unite and shriek against the raging wind.\*

They recognize, as I have said, a superior power that produces the effects which they witness, and we learn from the myths that early man's conception of that power was that it came from gigantic animals in the sky resembling those with which he was familiar on earth, such as the fierce beasts to whose constant attacks he was at that early period especially exposed. Thus, in the early Asiatic myths, the thunder is a huge bellowing bull that drags a great wagon across the sky, the noise of the wheels of which is heard in the rumbling sound that follows; the lightning is a great sinuous serpent that darts from the sky with a zig-zag motion and strikes with the same deadly effects as the venomous serpent of the earth, and the whirlwind or hurricane is a great wild boar that tears up the earth as he rushes along. We find the same general conceptions among the American aborigines. To the Indians of the Northwest coast, the thunder is a huge bird that sweeps across the sky, the noise being the flapping of his great wings, and the rumbling sound that is heard is the flapping and cry of the young brood that follows him; and the Tupas of Brazil believe that the watering of their crops is by this great bird, who admonishes them of his presence, by the mighty sound of his voice, the rustling of his wings and the lightning that flashes from his eyes.† Among the Algonquins the lightning was an immense snake,‡ and among the Hurons the hurricane was a gigantic serpent who had on

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\* J. A. Farrar's *Primitive Manners and Customs*, p. 2. Schwartz, *der Ursprung der Mythologie*, p. 46.

† Brinton, *Myths of the New World*, 2d ed., p. 108. ‡ Id. 118.

his head a great horn with which he tore up the trees and everything that stood in his way.\*

These illustrations might be greatly multiplied. De Gubernatis in his work on Zoological Mythology has given an account of 119 mythical animals of this kind ranging from the elephant to the ant; all of which have their prototypes in the animals that exist upon the land, in the water or in the air, in whose existence, supposed attributes and powers man has believed; and I am disposed to think that the worship of animals by the Egyptians, whatever changes it may afterwards have undergone, had its origin in the first stages of their civilization when, like other primitive people, they may be supposed to have believed that the physical phenomena they witnessed, especially in its destructive effects, came from animals in the sky, whose power they dreaded, whom they thought it necessary to conciliate and who consequently became objects of worship as supernatural forces. This appears to me more probable than any of the reasons that have been given for the origin of this strange worship by the many writers who have considered it, from Diodorus Siculus to Wilkinson.

From this first conception of gigantic animals throughout the sky, from whom proceeded all the effects that man witnessed, he came to the further conception of great creatures that not only combined in one the powers of several animals, but were endowed also with human intelligence; as we find in the images of Assyrian gods with the body of a bull, the wings of a huge bird and a human head; thus uniting the greatest animal strength and the fullest power of flight with the

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\* Brinton, p. 119.

highest intellectual capacity ; after which comes the conception of Gods, wholly in the human form, but with the power of transforming themselves into animals of any kind, and the final conception of one or more superior Gods, the greater deity having his abode in the sun, or constituting the sun itself, the next in the order of superiority being the moon, with the domestic relation between the two of man and wife, the sun being regarded as representing the masculine principle and the moon the feminine ; the first representing the ruler of the heavens and the latter of the earth ; the sun in the oldest civilization, that of Egypt, being worshipped under the name of Osiris and the moon as Isis, or the earth ; and this worship of the sun and moon existed not only in Egypt, but, under different names and forms, in the ancient civilizations of Asia and largely among the aboriginal tribes of America.

The recognition of what was beneficent in the operations of nature was of slower growth, and it was this that ultimately led to the worship of the sun. It was the most conspicuous object in the heavens, the source of light and heat, and the cause of the fertility of the earth, and was therefore regarded, or rather the god that personified it, as the most beneficent thing in the universe. But this was not the case everywhere. To the African, in certain parts of that continent, as well as to the Arab of the desert, it was not the sun, to whose burning heat he was exposed during the day, but the moon, that chased away the darkness and by whose light he could travel in the cool, refreshing period of the night, that was the beneficent deity. But in more northern countries where the change of the seasons brought about

the alternation of heat and cold, the sun was looked upon as the source of all fertility, and the most beneficent of Gods.

To primitive man there was nothing more mysterious than the transition from day to night, from light to darkness, and nothing in the operations of nature is so interwoven in the myths of early nations as this. The general idea was that there was a conflict constantly going on between the great beneficent spirit represented in the sun, by whatever name the Sun God was called among different people, and the spirit of evil, whose form was either that of a great serpent, or dragon, or some other huge object, whom the sun god was constantly attacking or resisting; the conflict between them in the air appearing in the storm, the tempest and the hurricane; the thunder being regarded as the noise of the strife, and the lightning, the darts that were hurled. And when the sun, after his apparent motion across the heavens, disappeared in the west, it was into the abode of the evil one that he went, the region of darkness, from which he arose victorious in the east in all the splendor of the dawn; the dawn being the loveliest object and the most grateful thing in nature, about which, and of its cause, the most poetical conceptions were formed, as that of a beautiful maiden, the goddess Aurora or Eos, who drove in her chariot of light in the pathway of the sun, as he rose, and moved upward, to burst forth in the fulness of his midday radiance.

This conception of a daily struggle between the powers of light and darkness was of Egyptian origin. The Egyptians believed in one supreme being, self-created and eternal, that existed apart and from whom

those higher gods that created and ruled the world, or struggled for the rule of it, emanated. These were especially three : Osiris, or the sun, Isis, the moon or the earth, and Typhon, the evil one or god of destruction, whose name appears to have survived, in the destructive wind of the Southern ocean bearing that name.

The Egyptians, observing the growth, decay and renovation that goes on in nature, believed, according to Prichard's interpretation of their mythology, that the whole world underwent the same process. That there was in the beginning a golden age of purity and innocence, but that man became so bad through the influence of the evil one, that the entire world was destroyed by a deluge and afterwards renewed, beginning again with a golden age. That this destruction and reconstruction had occurred many times, there having been several golden ages, and that there would be more, until at last, the world would be forever destroyed by fire.\*

Fire was another physical feature of the earth which to early man was mysterious. Not fire as the means of light and heat, but fire coming out of the earth, as an eruptive flame, or breaking forth in the violence of the volcano. In that part of Asia where fire in this mysterious form was chiefly to be seen, it gave rise to one of the great religions of the world, that of Zoroaster, or the worship of fire, a religion that, in the high degree of its morals and the spirituality of its conception, is the nearest to Christianity of all the ancient faiths.

In the N. W. corner of Persia is Azerbaijan, the most fertile and the most beautiful of the Persian prov-

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\* Prichard's Egyptian Mythology.



inces. It is the land of the Ghebers or Fire Worshipers ; a volcanic table land, exhibiting everywhere the proofs of the former action of fire ; and fire is still beneath its surface. To the eastward, jutting out from the western shore of the Caspian Sea, is the lofty peninsula of Apsheron upon which, not far from the town of Baku, is Sourikhani, meaning in the Persian tongue the field of fire, which since at least 1,000 years before Christ has been the holy place of the Ghebers ; its selection as such being due to the circumstance that wherever you there bore a hole in the earth, a burning gas springs up. Here is the sacred temple of the Fire Worshipers with its outward wall perforated by numerous chimneys. Within the enclosure in different parts are altars from which an inflammatory gas arises and in the centre, or in the temple proper, which is open on its four sides, there is a huge jet of a greenish yellow hue, which rises to about the height of three feet, waving to and fro, in which the worshippers recognize, and prostrate themselves before, the mystery of a perpetual flame. The worshippers are now reduced to a mere fragment, the chief portion of them being the Parsees of Bombay, and the mystery has ended in the fact that the soil beneath is a great field of petroleum.

The myths, which show what these early ideas were respecting physical phenomena, are found largely in the Aryan mythology, which is the most satisfactory, for when the Rig Veda or Aryan hymns that contain them were composed, this great race was still in the pastoral state and as it was to a very great extent the parent race of the Hindoos, the Persians, the Greeks, the Romans and of nearly all the nations of modern Europe and

America, these myths can be traced through the early mythologies of these different nations, and are thereby more clearly interpreted.

The Aryans, being a pastoral race, filled the heavens above them with imaginary creatures or objects that are found in the pastoral state, such as the bull, the cow, the ram, the sheep and many of the domestic animals, as well as the scenery and other objects that exist in that state. In the clouds they recognized the celestial cow from whose teeming udders came the moisture that refreshed the earth, celestial maidens who drew the water from fountains and poured it down in rain, and in the soft colored light that appears through the clouds was seen the golden raiment of these celestial virgins.\* A scudding cloud was a horse flying from his pursuers, and the strong winds were antelopes driven by the *maruts*, who direct their course as they rush across the heavens. It was very natural that a people living in the pastoral state, who had constantly before them the clouds in all the changes and diversified forms they assume, should, being wholly ignorant of their true nature, imagine that they saw in the region above them mountains and valleys, rocks, caverns, gigantic animals and forms in human shape. There were also, in addition to this, to mislead them, those atmospherical or optical illusions, such as the forms of men, animals, and other objects reflected against the clouds, as in the Brocken of the Harz, or the mirage of the desert, the rainbow and the double rainbow, the aurora borealis, the milky way, shooting stars, meteors, comets, and other illusions; and as everything they imagined they saw in the clouds was in motion and con-

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\* Kelly's Curiosities of Folk-Lore, p. 7.

stantly changing, it was natural also that it should lead to the further conception of what these imaginary beings were doing, and that out of their supposed actions, passions or affections that these early people should weave, or put together those mythic tales or legends, which reveal to us what their ideas of physical phenomena were.

When the myth in its progressive course had reached the conception that the heavens and the earth were ruled by beings in human shape, who were endowed with supernatural powers, great additions were made of gods and goddesses, whose acts, conflicts and struggles with each other, as well as those of their higher gods, made up a large part of the mythology ; and this was further increased by the conception of innumerable invisible spirits of all conceivable kinds that existed in the air, upon the land and in the water, some of whom were malevolent and others friendly, until at last every mountain, hill and valley, every fountain, river or stream, had its appropriate spirit or many of them ; which led, especially among an imaginative people like the Greeks and others of the Aryan stock, to the most poetical conceptions of their nature, powers, influence and acts, and out of this grew a mass of legendary lore, much of which survived to a very recent period in the customs, sports and amusements of the peasantry of Europe when the legend itself was forgotten.

I have thus, at considerable length, for it was difficult to compress within narrower limits so extensive an inquiry, undertaken to show what was man's earliest idea of the causes of physical phenomena. To express it briefly, it was, that it all came from the acts of creatures of his own imagination, that peopled the space

above him, to whose beneficence or malevolence he attributed all that was beneficial or injurious to him that took place in nature, and this continued to be his belief during the rise, maturity and decay of great civilizations. How could he come to any other conclusion? Ignorant of the form of the earth, of its daily revolution upon its axis, of its movement around the sun, and of many physical laws with which we are familiar, there was nothing apparent to him but supernatural agency to account for much that he witnessed. His idea of the earth was such as would naturally arise from his position upon it, and the evidence of his senses; that it was a flat, round plain diversified by the irregularity of mountain and valley, with the concave vault of the heavens above it. This was the fundamental idea alike among savage or civilized races, each race or people supposing that where they dwelt was at, or about, the centre of this plain. The sun was supposed to move around it, and the dark region below, into which he descended, and from which he arose in the morning, was the abode of evil spirits and of the spirits of the wicked among men; the entrance to which the Greeks fixed in the Western Ocean, north of the entrance to the Mediterranean; but according to Moreau de Jonnes, before referred to, the earlier and more general belief was that the place of entrance was the Cimmerian Bosphorus, now known as the Strait of Yenikale or Kertch, that connects the Sea of Azov with the Euxine or Black Sea. It was supposed that this great plain or flat earth was surrounded on all sides by an ocean, and that the vault of the heavens was supported by high mountains which were situ-

ated near this ocean at the extremity of the earth. As to how the earth itself was supported, there were different impressions among different people. Thales, the Greek philosopher, and Seneca, six hundred years after him, thought that it floated upon water or some other liquid substance; Anaximander and other Greeks, that it was in the form of a cylinder, the upper part of which only was inhabited, the cylinder floating in the centre of the celestial vault, because there was no reason why it should move from one side to the other. Hesiod and others appear to have thought that it was fastened by roots, the Chinese that it rested on the back of a great tortoise, the Hindoos, upon four elephants that stood upon a tortoise, the Aryans of the time of the Vedas, that it stood upon twelve columns between which the sun and moon passed through. But our time will not admit of enumerating more of these conceptions.

When or by whom the rotundity of the earth was first conceived we do not know. All that we know is that a late Greek writer, Diogenes Laertius, says that Parmenides,\* an aged follower of Pythagoras, who came to Athens in the time of Socrates, was the first person who asserted that the earth was of a spherical form and was situated in the centre of the universe; which may be true, as we know that Socrates believed the earth to be a globe which was kept fixed in its place by the pressure on every part of it of the surrounding atmosphere, which he said he had been told by a learned person. Aristotle, fifty years later, came to the conclusion that it was round, from the form of its shadow upon the sun during an eclipse and from the fact that in going across a

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\* Diogenes Laertius. B. IX., Parmenides.

level plain or in passing over the sea, the upper part of an object became visible before the lower, and his general view was that the earth stood immovable and was the centre of the universe. This continued to be a general belief among subsequent geographers down to the time of Cosmas, in the sixth century of our era, who disputed it and maintained with what were very ingenious arguments at that time, that it was an oblong plain enclosed upon its four sides by high walls.

In my annual address upon the history of Cartography, I gave a very full account of all that we know respecting the earliest conception of the earth's rotation upon its axis and its movements around the sun. It will suffice for this occasion to state that more than four centuries before our era, it was suggested by Heraclitus of Ephesus (B. C. 513), that the earth moved; that Philolaus, who was a contemporary of Socrates, maintained that it made a daily revolution around what he called the central fire; and we have it upon the authority of Plutarch that Aristarchus of Samos, B. C. 280, taught that the sun was a fixed star, that the earth moved around it in an oblique circle as well as upon its axis, a theory close to, if it does not embrace, what was afterwards proved by Copernicus.

But the idea that the earth moved found few adherents. Aristotle did not believe it, and Ptolemy, the last of the great geographers, who wrote in the second century of our era, ridiculed the idea that the heavens were immovable and that the earth turned upon its axis, and the world agreed with Ptolemy for thirteen hundred years. Even the idea that it was a globe could not have met with general acceptance, when so great a

writer as Tacitus, who lived in the first century of our era, disputed it.

It is not remarkable that it should have been so, for the discovery of the earth's form and movement is among the great triumphs of the human intellect. The discovery of its rotary motion and its motion around the sun was especially so, for it was one of those discoveries that could not have been made by chance, but must have been the result of long observation and patient thought ; and when it was reached by some bright intelligence, we can readily see that it was almost impossible to get men to believe it. It was difficult to get a man to believe against the evidence of his senses, that the heavenly bodies that he saw in motion, were really not moving, but that it was the earth itself that was in motion ; that the earth, instead of being the flat plain that he saw, with its mountain elevations and sloping valleys, was in fact a round ball or globe, and that instead of being the steadfast immovable thing, that it appeared to him as he trod upon it, it was flying through space at the rate of 74,143 miles an hour, or more than 20 miles a second.

I have only to add to my former observations upon this subject, the probability that the idea that it was not the heavenly bodies but the earth that was in motion did not originate with the Greeks, but came from the Egyptians or the Babylonians. In descending the Nile the passage in certain parts, as we know from ancient writers, was made very rapidly, and as the descent of the Euphrates was made in boats with a light framework of wood covered with skins, they would pass down that river quickly, so that the optical illusion, when we are sailing rapidly

close to the land, that it is not the boat that we are in, but the houses and objects upon the shore that are in motion, must have been one of constant observation ; and as these two nations watched and studied the movement of the heavenly bodies more than any of the nations of antiquity, it may have been that the apparent motion to which I have referred called their attention to the possibility of phenomena of the same nature in the sky, and that like the boat, it was the earth, and not the stars they were looking at, that was in motion.

The belief that this was an Egyptian idea derives support from a statement made by Miss Amelia B. Edwards in her recent lectures in this city, that inscriptions have been found in Egypt, one of which refers to the earth as one of the moving stars, and another that the earth when created was sent out revolving in space.

What we do know is that, whatever may have been the opinion of a few learned men, the general belief of the people was that everything in the nature of physical phenomena that they witnessed either in the sky, or upon the earth, came from supernatural agency.

This was the case in Rome in the time of Lucretius, whose celebrated poem upon the Nature of Things, which was written during the century that preceded our era, was largely devoted to showing that thunder, lightning, storms and other physical phenomena were not, as people supposed, the acts of the Gods, but arose entirely from natural causes. If, says Lucretius, Jupiter and the other Gods shake the heavens with thunder and hurl the lightning whenever they see fit, why do they strike with it the innocent as well as the wicked, and if they hurl thunderbolts at men, why do they do so in solitary places?



Is it to exercise their arms and strengthen their elbows ? Why does Jupiter hurl his thunderbolts into the sea ? Of what does he accuse the waters ? And why does he shatter the sacred temples of the Gods, as well as his own temples, even disfiguring his own image ?

After an explanation at great length of the Epicurean theory of atoms, which may be called a materialistic theory of evolution of the broadest possible kind, Lucretius gives an exposition of the causes of natural phenomena, which, I infer from a passage in the poem, he had worked out chiefly himself. The explanations he gives are striking for the time, for, although he cannot be said to have entirely anticipated subsequent discoveries, it is remarkable how near he came, in many instances, to the true explanation.

A few illustrations will suffice. The clouds, he says, attract the moisture from the rivers and the ocean, and after being driven about by the winds, return it to the earth in the form of rain. His explanation of thunder and lightning is this : The clouds become heavily weighted with moisture and while they are in this compact state, they are driven by the winds violently against each other, a movement or collision that generates heat, and they have in addition to this heat derived from the sun. The wind, though it is invisible, has a substance, and when it strikes violently against these heavily weighted clouds, it produces fire, as fire flies out when we strike a stone with iron. The winds also, when they blow violently, create heat by their own motion, and in these various ways, he says, nature forms an *attenuated fire* composed of the minutest particles of flame, with the subtlest motions and atoms, so that nothing whatever

can resist it ; indicating very clearly, that he had some conception of the nature of electricity. At the time of storms all parts of the clouds, he continues, are replete with wind and fire. They contain atoms of heat with a vortex of wind compressed within the cloud, which, growing warm by its own motion and by its contact with fire lightning is formed, and this, struggling to escape from its place of imprisonment, suddenly bursts through, and the consequent tearing apart and rending of the cloud are heard in the loud crack of the thunder. In some cases, however, he says, the cloud is so condensed and compact, that the fire and wind within it cannot suddenly burst through but force the cloud down to the earth, in the form of a water-spout.

Earthquakes, he says, are the result of the movement of the air through the caverns, fissures, and open spaces beneath the surface of the earth, where, in addition to these airy caverns, there are hidden rivers, lakes, and pools. The wind crowds itself into these hollow places beneath, where it rages with violent fury, bringing down these vast caverns in violent shocks ; or they fall from age, and, as they fall, the earth at the surface quakes. He wholly ignores all supernatural agency, seeking to explain everything by natural causes, and the examples I have given will show what a close observer of nature he was.

In an address like this it is not possible to state, except in the most general way, what was done by the Greeks and the Romans to advance the knowledge of physical geography. The Greeks, to the time of Aristotle, did little, for the Greek philosophers, from Thales downward, instead of accumulating facts and drawing such deductions as the facts warranted, began by conjectures as to

the origin and nature of things, and, having adopted some hypothesis, sought for such facts as would support it ; a course that, instead of advancing, retarded the development of the physical sciences.

Aristotle wrote upon atmospheric phenomena, especially upon the winds, in which this great man was not as successful as in his other labors. The winds had a great attraction for the Greeks, and their ideas on the nature of this invisible force rendered it especially suitable for the purposes of their poetry. Four are mentioned by Homer and may be taken, as Bunbury has suggested, as representing in a general way the four cardinal points. They were *Boreas*, the North wind, the bringer of fine weather, although strong and violent, *Notus* the South, or wind of sudden squalls, *Zephyrus* the West or stormy wind, and *Eurus* the East wind, which is but seldom mentioned by the poet.\* Strabo says that some writers held that there were but two principal winds, and that the other winds were only slight differences in the direction of these two ; which he holds to be erroneous, upon the authority of Aristotle and Timosthenes.†

Timosthenes, B. C. 282, a native of Rhodes, who was an admiral in the fleet of Ptolemy Philadelphus, wrote a book, that is now lost, upon harbors, for the benefit of mariners, in which, as we learn from early writers, he distinguished the different countries in their relation to the Mediterranean, which was then thought to be the Central Sea, by the direction from which the winds came ; enumerating twelve different winds, which was the num-

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\* Bunbury's *Ancient Geography*, vol. I, pp. 36, 37.

† Strabo, B. I., C. II., 21.



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ber that Aristotle had previously fixed upon ; and the division of winds into the number of twelve appears to have been generally accepted thereafter, for we find Seneca, A. D. 60, stating that there were twelve and no more.

Posidonius, B. C. 86, from observations made upon the tides of the Mediterranean, came to the correct conclusion that they were affected by the influence of the moon. He also studied the phenomena of earthquakes and volcanoes, and appears, from the fragments of his writings that have come down to us, to have had a very clear conception of changes in the earth's surface produced by the movements of elevation or subsidence through earthquakes or other physical causes.

Strabo, A. D. 21, in the account which he gives of different countries, in his geography, the most valuable one that has come down to us, brought together much that related to physical geography respecting rivers, mountains, mountain ranges, climates and other matters ; and a century after Lucretius, Pliny the Elder devoted one of the books of his Natural History exclusively to an exposition of the earth and the physical phenomena connected with it. Pliny, however, was not, like Lucretius, an original thinker. He was a compiler ; a man of great industry, who, it would appear, brought together in this particular book whatever he found in the writings of his predecessors or contemporaries respecting the earth and its phenomena, which he arranged under appropriate heads, adding occasionally suggestions of his own. I infer this from the fact that at the end of the book he gives the names of forty-four writers, many of whose works have perished. In addition to which, some of his explanations are inconsistent

with each other, and in certain passages it is difficult to understand exactly what he means. He represents the earth as a ball fixed immovably in the centre of the universe, around which the other objects in space revolve, a misconception that makes many of his explanations of physical facts erroneous. Yet Pliny's work is very valuable, as it evidently contains a very full account of what the learned believed in his time, and shows that considerable progress had been made in this branch of knowledge. Like Lucretius, he ignores all supernatural agency, his explanations in every instance being from supposed natural causes, and yet, what was remarkable, he was a believer in omens and presages, such as, that earthquakes denoted the occurrence shortly thereafter of some great public calamity. His work was long one of authority, and with him ends what I shall have to say of the ancients.

The subject of Physical Geography in the Middle Ages has been investigated by Dr. Konrad Kretschmer, of Vienna, in a work published during the past year, and I cannot present this branch of my inquiry better than by giving a concise statement of the conclusions arrived at by this learned writer, which are sustained by a great number of passages that he has brought together from the works of various writers of that period.

His conclusions may be substantially stated as follows :

The modern conception of geography was not in any sense possible in the Middle Ages. The spirit of those days was essentially a religious one, and it was deeply fixed in the minds of men that the whole circle of science corresponded in its form to the religious idea. What-

soever failed to manifest a direct relation to the spiritual being of man was thrust aside, or pushed, at least, into the remote background. This was the leading idea, even in the works that professed to give descriptions of nature. Men saw in collective nature only the work of God, and they held, therefore, that religious belief alone was able to form conceptions of nature and to explain the phenomena of the creation. Clement of Alexandria, in the fifth book of the *Stromata*, denounces the heresy which admits a distinction between faith and knowledge, and affirms that these are essentially the same and rest on the same foundation. "I believe," he says, "in order that I may understand." Tertullian will hear of no such thing as inquiry. "When we really believe," he says, "we have no desire to believe anything beyond that which we have. For we accept this one thing, that there is nothing farther that we ought to believe."

With such principles the men of the Middle Ages, instead of seeking the origin of phenomena, assumed imaginary causes for them, and the scientific activity of the period spent itself, not in investigation, but in argumentation. Even after the writings of Aristotle had been made known to Western Europe by the Arabian culture, the theological bias controlled the minds of men, and Physics is always treated in their books as a part of Metaphysics.

The ground was moreover too limited for the construction of Physical Geography. The idea of a division of labor in the field of natural science was not yet conceivable. It was the time of those all-embracing mirrors of nature, encyclopædias and summaries which had the Cosmos in all its parts for their subject, the organic,

as well as the inorganic, world. The term geography is hardly ever met with, but in its place we find the expressions, "the nature of things," "the measurement of the world," "the universe," and "the nature of places." In the cloister schools, geometry included geography and the description of nations and countries.

Two influences dominated the intellectual life of the Middle Ages; the influence of the Bible and that of classical antiquity, and dissimilar as these were, each was regarded as an authority not to be questioned; and the natural world was interpreted, not by observation and by comparison of facts, but by some text from Genesis, or by some passage from Aristotle. It was not under such conditions that a Physical Geography could be developed. So far, Dr. Kretschmer.

When Copernicus, whom Kepler calls a man of "vast genius," in the 16th century had proved that the earth revolved daily upon its axis and moved annually around the sun, and Bacon's inductive method was generally accepted as the proper mode of investigation in the physical sciences, the basis was laid upon which to found such a science as Physical Geography, but many years elapsed before it took that form.

The great age of maritime exploration and discovery from the 15th to the 17th century resulted in the accumulation of a large amount of physical information respecting the earth, but a long time elapsed before it was made use of in a scientific manner.

Bacon, after the publication in 1620 of his *Novum Organum* projected as a third part of his *Instauratio* what he called a Natural and Experimental History on Phenomena of the Universe, and prepared a catalogue



of the subjects upon which he proposed to write distinct treatises, or as he called them, particular histories, when his time would permit, which were each to begin with a series of interrogations as to the points to be investigated, and the residue of the treatise was to be devoted to answering them. It was an ambitious undertaking, for he catalogued the large number of one hundred and thirty-one distinct treatises, eighteen of which were to be devoted to subjects chiefly relating to atmospheric phenomena. Of these eighteen projected treatises he prepared only two, one of which he called the "History of the Winds" and the other "On the Ebb and Flow of the Sea," the first of which he published a few years before his death. These two show that he was but indifferently qualified for the investigation of the subjects proposed in these eighteen treatises, for, as Humboldt has pointed out, his mathematical, astronomical and physical knowledge was very limited, even for that age, or as Humboldt puts it, he was in these branches of knowledge "far behind his contemporaries."\*

The tract upon the Ebb and Flow of the Sea is, as respects the cause of the phenomena, throughout erroneous. Contrary to what is now accepted, he maintains that the movement is not one of elevation and depression, and the assumption that it was in any way due to the influence of the moon, because of a comparison between its motion and the motion of the moon, he dismisses as a "hasty anticipation;" declaring that "to a careful inquirer, there are certain traces of the truth that may lead to a surer conclusion," and before

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\* 3 Humboldt's *Cosmos*, p. 106, London, 1851.

setting forth what that “surer conclusion” was, I should state that he did not accept the Copernican theory of the movement of the earth, but refers to the assertion that it rotated upon its axis as an “extravagant notion.” He not only believed that the heavens revolved around the earth, but sought to account for the course of the east tropical wind, by the suggestion that the atmosphere also probably moved with the heavens around the earth. His explanation of the reciprocal action of the tides once in six hours was this. Erroneously supposing that not only the heavenly bodies but, as he expressed it, the whole universe moved around the earth from east to west in twenty-four hours, he concluded that the sea, being a fluid, moved also in the same direction and that it would move with the heavenly bodies entirely around the earth, but for the fact that its movement was checked by the two hemispheres, the Old and the New World, which, extending through nearly three zones of the globe, acted like a rampart. This, he says, gives a double reaction to the entire mass of waters, thus making a visible ebb and flow twice a day; there being “a double advance and also a double recoil.”\*

His treatise on the winds contained many observations respecting them that were accurate. He discarded the idea of the ancients that there was a fixed number of winds, declaring that there was not a region in the heavens from whence the winds did not blow, and that if you divided the heavens into as many degrees as there are in the horizon, wind would sometimes blow from every one of them, as all impulsion of the air was wind; but he recognized the existence of prevailing winds such

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\* 3. Bacon's Works, 526, Am. ed.

as the trades. He knew that the general cause of winds was the action of the heat of the sun upon the moisture or vapors that arise from the earth, and appears to have had a general idea of the influence of heat and cold upon their movement without exactly reaching the general scientific truth that wind is a current of air in the atmosphere, ordinarily caused by the inequality of the temperature of adjoining regions.\* He frequently speaks of the nurseries of the winds in the clouds, or otherwise around the globe, which generate and send them forth; but he was not very clear on this point, nor with regard to the direction of the winds; for his want of knowledge of their deflection from their original line, with respect to the surface over which they blow, by the rotary motion of the earth, made much that he had to say about the causes of the direction and movement of winds of very little value.

It was otherwise with Bacon's great contemporary Des Cartes, whom Hallam calls "the pride of France and the wonder of his contemporaries," for Des Cartes was an excellent mathematician and a good astronomer, who considered that Copernicus had absolutely demonstrated the correctness of his theory of the movement of the earth. Taking that for his foundation, Des Cartes wrote a work upon the physical history of the earth which he never published, or even showed to his friends, when he found after its completion, that Galileo for maintaining the Copernican theory had, by order of the Inquisition in Rome, been thrown into prison and compelled to sign a document abjuring his belief in that theory. Des Cartes in writing to a friend in 1633 says, after hearing of Galileo's

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\* Cooley's *Physical Geography*, p. 163.

condemnation, that he had almost resolved to burn his papers, or to let no one see them. "If," he says, "the idea of the movement of the earth is false, then the whole foundation of my philosophy is false, for it is so bound up with all the parts of my treatise that I should not know how to detach it, without making all the rest defective. But as I would not, for anything in the world, that any discourse should proceed from me, in which there should be the least word disapproved by the Church, I prefer rather to suppress my work than that it should appear limping and defective"; and he did suppress it.

In the same year, 1633, he published his *Meteora*, a name then used for atmospheric phenomena, from which he carefully excluded any reference to the movement of the earth, but, on the contrary, inserted a passage to the effect that the entire atmosphere moved around the earth from east to west; which, as I interpret the passage, for it had no necessary connection with the subject that he was then treating, was done to satisfy the Church, as it left upon the mind of the reader the impression that the earth was immovable, without the author's absolutely asserting it.\*

In this work he investigates the nature of the exhalations and vapors drawn up from the earth by the heat of the sun in producing clouds, winds, rain, hail and snow. Every sensible agitation of the air he regarded as wind; holding that the winds arise from the difference in the nature or constitution of vapors and the irregularity and variety of the surface of the earth over which they blow, for at sea, he says, where there is no irregularity, they blow more regularly and are stronger. Snow, he thought, was formed

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\* See Appendix.

in the clouds by the cold acting upon the upper surface of the vapors, and that storms and tempests were due to the clouds descending rapidly and driving the air with such force before them as to create a great wind. He considered that thunder, lightning and whirlwinds had their origin from many layers of clouds being disposed one over the other, like stories in a house, and were produced by the upper layers falling with great violence upon those that were below ; and he appears in this treatise to have been the first to explain the cause of the rainbow. He considered, also, the subject of the ebb and flow of the sea, and supposed he had found its explanation in his theory of vortices, which, however, failed to solve the problem, and need not be dwelt on in this place.\*

A few years after the death of Des Cartes, Du Hamel, a writer in his day of considerable authority upon scientific subjects, published in 1659 a treatise upon atmospheric phenomena in the form of a dialogue between three persons, Theophile, a zealous believer in the ancients, Menander, a passionate partisan of Des Cartes, and Simplicius, in whom Du Hamel personified himself, who adopts the side of neither, taking, as he professes, from each what he considers the best. The author in so doing and in the general carrying out of his plan showed himself rather unfavorable to, or at least inappreciative of, the views of Des Cartes.

There was nothing connected with atmospheric phenomena that interested scientific men in the seventeenth century more deeply than the subject of the winds. This was due to the opening up of a large

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\* See Appendix.

portion of the globe during the age of maritime discovery, which made men familiar with the disastrous tempests, hurricanes, cyclones and other disturbances that are so frequent in the equatorial and southern seas, and also the fact of the trade winds and monsoons, a correct knowledge of which was then highly important for the purposes of navigation. The question, therefore, of the origin of the winds, the cause of their movement and their direction was one of great practical value, the investigation of which had not been confined to Bacon and Des Cartes, but had been written upon by Galileo, Fournier, the French geographer, Riccioli, the Italian geographer, Kircher, the mathematician, physicist and naturalist, Boyle, the philosophical chemist, Isaac Vossius, the son of the historian, and others; but the most useful contribution during this period to this important inquiry was a small volume by R. Bohun, of New College, Oxford, entitled a "Discourse upon the Knowledge and Properties of Wind," which he published at Oxford in 1671. The references that Bohun makes throughout his book show that he was thoroughly well informed of all that had been advanced respecting the winds from Aristotle to the writers of his own period. He had not much respect for the opinions of the ancients, or for assertions which he said had "been long received by the world from the great reputation of their authors"; and he especially refers to those which had been set down by Aristotle in his *Meteors* and *Book of Problems*, pointing out that Bacon, in respect to the qualities of the wind, had followed exactly in the traces of Aristotle. "The world has been so long imposed upon" says Bohun, "by traditions, that we must in the

first place be thoroughly informed upon all matters of fact to ascertain what hypothesis facts will justify, which must be the result of long experience and observation, for a full collection of the properties and effects of wind must be the work of posterity and may require many ages. I have, therefore," he says, "taken a larger compass than the generality of writers and derive the origin of the winds from several causes which I have rather endeavored to prove from accounts of sea voyages and relations of matters of fact, than to refine on them by any nice speculations of my own." He had, for the time, a very clear conception of their cause, of the condensation of vapors by cold, and the rarification of them by heat, and he gave in his work a considerable amount of useful information that he had collected from shipmasters, especially respecting the trade winds and monsoons, as well as about tornadoes, cyclones and other atmospherical disturbances. He neither admitted nor denied the Copernican theory, and the defect in his book is that he prefers to rely upon such reasons as will accord with the belief in the earth's immovability. He earnestly urged that shipmasters, especially those who made long voyages, should be required to keep a record of their observations that might be available for investigation and comparison; a plan which the United States Coast Survey, two centuries afterwards, adopted to get information respecting the winds and oceanic currents by what are known as Maury's charts.

With the exception of what may have been done by Des Cartes, and that was not given to the world, no attempt was made to arrange and systematize the large

amount of physical information respecting the earth that had been gathered in the age of maritime exploration, to make use of this new material as a whole and show the results that it warranted, until 1630, when Bernard Varen, a physician of Amsterdam, better known by his Latin name of Varenius, published in that city his *Geographia Generalis*, a work so original, and so unlike anything that had preceded it, that it brought about a new era in the study of geography. He was the first to separate what he called general or universal geography from that which is special or particular; meaning by general geography all which relates to the earth as a whole, and by special or particular geography, the description of countries, and what was peculiar or incident to them. It was not a treatise wholly relating to physical geography, for a large part of it was devoted to what was mathematical, together with other things, such as the art of navigation and the building and loading of ships. The larger portion of it, however, contained what now comes under the head of physical geography, and was remarkable at that time for the extensive and accurate information which Varenius had of the earth's surface and of physical facts relating to it, much of which was not then to be found in books, and must have been obtained by him from shipmasters, merchants or others in Amsterdam, or in records of voyages kept there and in other Dutch cities; for Amsterdam was at that time a great sea-port, which, together with other towns in Holland, maintained an extensive commerce throughout the world, and sent out maritime expeditions to remote or unknown parts in order to open up new sources of traffic.\*

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\*Holland at this period possessed nearly half of the merchant marine of the world. Émil Michel, *Revue des Deux Mondes*, t. 96, liv. 4.



In the log books kept during such voyages would be found everything new that had been observed respecting winds, currents and many other matters that were useful in navigation or important for the purposes of trade, and the enterprising and enlightened merchants that sent out these expeditions would, after these voyages were over, preserve the log books, as what they contained would be of use in further adventures. To this source of information Varenus undoubtedly had access, and the admirable use he made of it appears in the general plan of his book and the way in which it is worked out.\*

The work deserves a more detailed exposition of its merits than it is possible to give in an address of this nature. It will be sufficient to say that it attracted the attention of Sir Isaac Newton, who thought so highly of it that he caused it to be reprinted in England, that he might use it as a text-book in his own lectures upon the same subject. It was afterwards translated into English and as translated passed through several editions, and was reprinted in other countries. For a century and a half it was a work of authority in universities and among the learned, and though, during that long period, many geographies were published, nothing of the same breadth and scope was produced† until 1817, when Karl Ritter published in Berlin, the first volume of his great work, *The Science of the Earth in its Relation to Nature and to the History of Man*; a work that during his long life was augmented to nineteen volumes, eighteen of which

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\* See Appendix.

† Exception must be made of Kant's remarkable lectures on Physical Geography, always a most interesting subject to him. These lectures were edited during his lifetime by his friends and pupils, and undoubtedly prepared the way for others. (See Appendix.)

are devoted to the continent of Asia alone. This work, from the very beginning, raised geography to a higher plane than it had ever occupied before, by disclosing the relation it had to the condition of man, the formation of nations, and the development and progress of civilization. Ritter, as he has said himself, studied geography as the physiologist and the anatomist study the human body, that is, by a careful and thorough investigation of the different parts to get at a better understanding of the unity and general purpose of the whole. To Ritter, every marked peculiarity upon the earth's surface had its function. The height of mountains and the distribution of mountain ranges, the great elevated plateaus, the sweeping valleys, the vast level plains, the arid deserts, the coast lines and situation of continents and of islands, the distributions of oceans and seas, and the great ice-bound regions at the poles, all had their appropriate functions as part of the general organism of the earth ; and this being specially adapted for the abode of man, its geographical features had a direct influence, not only upon his material state, but in the bringing out of his moral and higher faculties : for Ritter was a profoundly religious man and saw, in the enormous body of facts that he had investigated and brought together, an arrangement, made by one great directing mind, that was wonderful in its wisdom, and but imperfectly understood by man.

But the carrying out of a scheme so widespread as this, was not one to bring about such a practical work as the establishment of a science of physical geography. This required a mind very different from that of Ritter. It demanded a man who could bring together the mass

of material that had accumulated since the days of Varenus, for during that long period several new sciences had been formed, and so arrange and present all that was then known of terrestrial physics as to lay the foundation for a distinct and separate science, and that man was found in Ritter's contemporary and life-long friend, Alexander Von Humboldt. I doubt if any man ever existed that had so great an amount of exact and positive knowledge as Humboldt. He was a specialist in six sciences : geography, geology, meteorology, physics, botany and zoology, and beyond this he was a generalizer of a high order, such as the world had not seen since the days of Aristotle.

When I met him in 1851, in his small apartment at Potsdam, he was seated at a table, drawing, as he told me, from memory, the outline of the Peak of Chimborazo, being dissatisfied with an engraving of the mountain in a work that had just been sent to him. I mention this incident to show how vividly the physical features of nature impressed him, and how enduring was his recollection of them.

In 1827 Humboldt delivered at Berlin sixty-one lectures on physical geography, five of which were devoted to its nature and limits, and by these, I may say, the foundation for that science was laid. The other lectures were upon special branches, such as the nature of the surface of the earth, the sea, mountain forms, volcanoes, earthquakes, the distribution of heat, terrestrial magnetism and the geographical distribution of plants and animals. These lectures were largely attended by the most learned and distinguished men in Germany. They created a great sensation at the time and drew

general attention to the subject throughout Europe. One of the results was the publication, by Berghaus in 1832, of the first part of his physical atlas, a work that was completed in 1837. This pictorial aid was of great value, for upon these beautiful charts the eye can take in at once what it is often difficult to convey by words ; and in connection with this should be mentioned the researches of Professor Dove of Berlin, the meteorologist, upon the laws of climate and other matters relating to atmospheric phenomena.

There remained one thing more to be done. Humboldt did not publish his lectures. He kept them to be used many years afterwards in the preparation of his *Cosmos*, although others published notes of such parts as they had taken down. What was required, therefore, was that some one should collect all the facts that were then known and arrange them systematically in a treatise that should present a view of the whole subject, and this was done by F. Hoffman, who published in 1838 his "*Physikalische Geographie*."

In 1848 Keith Johnston published his great physical atlas, and in the same year appeared Mrs. Somerville's *Physical Geography*, which presented the subject to English readers in a most attractive form, for this lady was not only distinguished for the extent of her scientific knowledge, but, like Ritter, she had the rare art of making scientific matters plain to the ordinary reader by her admirable arrangement of the subject, and the clearness and felicity of her style. I know of no work within the same limits that has a great amount of valuable knowledge so perspicuously set forth and so admirably arranged, a characteristic to be found also in



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her former work on the Connection of the Physical Sciences ; and as my paper will close with this interesting lady, I may add that, in addition to her great scientific attainments and labors, she was distinguished for the physical beauty of her person, her gentleness, the charm of her conversation, and her truly feminine character in all the relations of daughter, wife and mother. I may add in conclusion that, like Ritter, her scientific researches strengthened her belief in the great truths of Christianity, to which she steadfastly adhered and from which she derived the greatest consolation, as she frequently declared, up to the end of her long life at the age of ninety-two.

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## APPENDIX.

### ARISTOTLE.

Aristotle's theory of the winds is that there is a two-fold exhalation from the earth, the vaporous and the fuliginous, rain being generated from the vaporous and from the fuliginous wind. The moist, he affirms, is not without the dry, nor the dry without the moist ; the two are mingled with each other, and contribute to the generation of each other.

The sun, being moved in a circle, at one time becomes northern and at another southern.

When he ascends he raises moisture from the earth and evaporates it ; but when he becomes southern, or declines, the vapor becomes thickened and is changed into water, and, falling on the earth, moistens it and the earth returns the fuliginous exhalation, like moist wood. In this way the exhalations generate each other.

There are four universal winds. Two of these, Apeliotes (the East) and Zephyrus (the West) are milder winds ; but the north and the south winds are violent.

The cause of this violence is that the sun does not heat the poles which are cold and moist.

Much rain being produced at the poles, much fuliginous exhalation ascends; and therefore the north and the south winds are vehement.

Winds are not so strong in the middle sea as near the shore, where the fuliginous exhalation rises; and on the tops of the highest mountains the air is tranquil.

The oblique motion of winds is explained in this way: all the air in the upper parts follows the motion of the universe, and the fuliginous exhalation, ascending as far as to the air and not being able to pass beyond it, vibrates to the downward parts and the winds become oblique.

Earthquakes are produced by causes similar to those which generate the winds. The earth is dry, but receives by rain much humidity, and, being heated by the sun and by the inward fire in itself, much spirit is produced both within and without, and the whole of this flows at one time inward and at another time outward. Spirit, being the most attenuated of substances, moves with the greatest celerity, and is on this account especially percussive and motive of bodies.

Thunder and lightning are extruded by compression from clouds, these being most condensed in the upper part, because of the cold, so that the thunder and lightning tend downward to the earth.

(Taylor's Aristotle, London, 1806-1812.)

#### DES CARTES.

The passage in the original is as follows: Sed jam speciatim proprietates & generationem principum ventorum contemplemur. Primò observatur, totum aërem circa terram ab Oriente ad Occidentem volvi: Idque hoc loco supponendum erit, cum commodè ratio diduci nequeat, quin totius universi fabrica simul explicetur; quod extra nostrum propositum.

(Renati Des Cartes Specimina Philosophiæ, etc. Amstelodami, 1656, p. 175.)

*Translation*—"But let us now consider particularly the properties and the generation of the principal winds. First, then, it is remarked that the whole atmosphere revolves (is revolved) around the earth from the east to the west: and this will have to be admitted in this place, because the reason for it cannot properly be set forth without explaining at the same time the fabric of the whole universe; and this is foreign to our purpose."

William Wallace in an article in the *Encyclopædia Britannica* gives this explanation of Descartes' theory of vortices:

The infinite universe is infinitely full of matter. . . . As the movement of one particle in a closely-packed universe is only possible if all other parts move simultaneously, so that the last in the series steps into the place of the first; and as the figure and division of the particles vary

in each point of the universe, there will inevitably at the same instant result throughout the universe an innumerable host of more or less circular movements, and of vortices or whirlpools of material particles, varying in size and velocity.

## KANT.

Prof. R. Adamson, in the *Encyclopædia Britannica*, ninth edition (*art.* Kant), enumerates as among the most important of Kant's contributions to physical science: 1. The tract, *Whether the Earth in Its Revolution has Experienced Some Change Since the Earliest Times* (1754). In this tract it is pointed out that the action of the moon in raising the waters of the earth must have a secondary effect in the slight retardation of the earth's motion, and the fact that the moon turns always the same face to the earth is referred to a similar cause: 2. *Explanatory Remarks on the Theory of the Winds* (1756), in which Kant observes that the varying velocity of rotation of the successive zones of the earth's surface furnishes a key to the phenomena of periodic winds; a theory that is in almost entire agreement with that now received.

## VARENIUS.

The originality and value, at the time, of Varenus' work, will be more fully appreciated when it is compared with the best geographical work that preceded it. This was Cluverius' introduction to general geography, the first edition of which was published in Leyden only twenty years before the appearance of Varenus' work and which, in the course of a century, passed through twenty-six editions, a remarkable thing at the period for any book. This geography was a great improvement upon its predecessors, because Cluverius discarded all the imaginary and absurd things that had deformed previous geographies from the time of the middle ages and confined it to what the author believed to be accurately known, and yet this popular geography had comparatively nothing respecting the physics of the earth beyond the statement that it was round, that the winds were named after the 32 points of the horizon, and a brief statement respecting the ocean; his general idea of which was erroneous, for Cluverius adhered to the Ptolemaic theory and believed that the earth stood immovable in the centre of the universe. In fact a few pages embraced nearly all that could be said to relate to physical geography, to which subject Varenus devoted nearly the half of his work.

In his first six chapters Varenus gives an admirable exposition of what geography is, after which he divides his book into sections, every section containing a number of geographical propositions, each proposi-



tion followed by a statement of the reasons and facts that support it. He considers the changes that have taken place in the earth's surface and the causes of them; how the ocean has in certain parts usurped the land and the land in others has encroached upon the ocean. He inquires into the origin of mountains, their rise and depression, why rain gathers around their tops, and gives a description of the principal ones and of volcanoes. The subject of the waters of the earth is extensively examined, from the ocean to natural fountains and mineral springs. He rejects the prevalent belief that the Pacific Ocean is higher than the Atlantic and the Indian Ocean higher than the Mediterranean, maintaining that by physical laws the ocean is of a uniform level throughout, and that there is no foundation for the statement of certain writers that if a canal were cut through the Isthmus of Suez the waters of the Southern Ocean would overflow the whole of lower Egypt. He expresses the opinion that such a canal is entirely feasible, and that this should have been asserted by him two hundred years before the canal was constructed is interesting, when it is remembered that up to the time when De Lesseps began the work of it engineers insisted that it was not practicable, in consequence of the inequality of level between the Mediterranean and the Indian Ocean.

He devotes a chapter to the subject of rivers, the causes that affect their form, their direction, the rapidity or otherwise of their course, the source of their supply and the general office they perform; pointing out the erroneous opinions the ancients had respecting them, especially as to the cause of the periodical rise of the Nile, which he correctly ascribes to the existence of great lakes and the mountains in the vicinity of the equator, and explains why the rise of the river begins and ceases at particular times. But the most interesting investigation he makes in connection with the movement of waters is as to the cause of the ebb and flow of the sea. He reviews the various opinions that had been advanced to account for the regularity of this movement, from the time of the ancients, such as the views entertained by some that the earth and sea were of the nature of a living creature, which by its respiration, caused the ebbing and flowing; of others, that it came from a great whirlpool near Norway, which, during certain hours, absorbs the water and afterwards discharges it in the same space of time. He rejects the theory of Scaliger, which, as stated in the text, was that of Bacon, that the motion of the sea was obstructed by the two hemispheres of the Old and the New World, and reverberated. He considers the cause assigned by most philosophers, that it was owing to the influence of the moon, but he says the question is, what is this influence, and they answer that it is an occult quality, or sympathy, whereby the moon attracts moist bodies;

which, he continues, are mere words signifying that the moon does it by some means, but they do not know why, which is the thing we want.

After reviewing the various reasons assigned, he thinks Des Cartes' explanation of it by his theory of vortices to be the most ingenious, but points out defects in his demonstration which make it contrary to experience, and finally comes to the conclusion that the moon some way or other causes this motion, that the flux is produced by the pressure of the moon, or the celestial matter between it and the sea, and continues no longer than the cause that forces it,\* which was about as near to the truth as it was possible to get until the discovery afterwards, by Sir Isaac Newton, of the law of gravitation.

Other subjects reviewed by him are the difference of climates and their cause, the causes of light, heat, cold, rain, etc., and the particular effect of the obliquity or perpendicularity of the sun's rays. The atmosphere is a subject that is especially dwelt upon, and its composition and nature are explained as accurately as the scientific knowledge of the time would admit. As the heat from the sun expands the vapors, he says, they require more room, and as the heat leaves them they require less, and that it is this constant change and interchange, this expanding and contracting that causes the winds, wind being merely a movement of the air; a motion that can be felt and that has force. He rejects the view entertained by some that the movement or commotion, as he calls it, is towards some particular point, as some are circular, and no wind exactly observes the same point, though there are particular or prevailing winds. The general cause, he holds, is the heat of the sun, which rarifies and attenuates the air, causing it to take up more space and press forward the air that encompasses it. That exhalations come from the land as well as the sea, but do not cause wind until they are rarified by the sun's heat, and that other causes are the melting of the snow upon high places and the descending and pressure of clouds from above. He explains the cause of the monsoons, and he gives many facts that he had collected respecting the winds and other atmospheric phenomena; and then follows a very full, accurate and practical exposition of mathematical geography, which takes up a large part of the work.

Until very recently little was known respecting Varenus beyond the fact that he was a physician in Amsterdam, and published his works in that city. It has now been ascertained that he was born in 1622 at Hitzacker, on the Elbe, in Hanover, that he passed his early life at Uelzen, where his father was court preacher to the Duke of Brunswick, that he studied at the universities of Königsberg and Leyden, and went to Amsterdam to practice physic, and died there in 1670.

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\* Varenus by Duydole, 236, 254.

## THE TIDES.

E. A. Wallis Budge in his *Babylonian Life and History*, page 145, mentions a Babylonian tablet found in 1883, upon which is an account of the contest between the great she demon of the sea Tiamat and Merodach the Lord of life and light, the mythical conception, as stated in the text, of the struggle between light and darkness, in which, he thinks, an early reference is made to the tides; that is, that "while the fight was going on she (Tiamat) apparently stopped the tides from flowing," which the God Merodach who conquered her rectified.

Strabo B. III. c v. § 9, says upon the authority of Posidonius, that Seleucus, a native of the country adjoining the Persian Gulf, states that the regularity and irregularity of the ebb and flow of the sea, follow the different positions of the moon in the zodiac; that when the moon is in the signs next the tropics. the tides are irregular both in their height and force, and that for the remaining signs their regularity is greater or less, according as they are more or less removed from the signs before mentioned.

Cæsar in the fourth part of the Gallic War, c. xxix, noticed that when the moon was full, "the maritime tides were greatest in the ocean," and Seneca, B. C. 38, speaks of the moon attracting the waters. This conception on the part of Seneca of what is the modern explanation of the principal cause of the regular action of the tides, the moon's attraction, is not so striking in his case, as he was a man of remarkable geographical insight, who was not only convinced of the globular form of the earth, but had the farther conception that what was then recognized as the only inhabitable part of it was inadequate to account for the amount of land that must exist in the same wide circle of the globe and that a great land would be revealed in the future upon the opening up of the ocean at the west; which appears in a passage in his tragedy of Medea, and although this passage has frequently been referred to by geographical writers, it may be appropriately given here, being always of interest as foreshadowing the subsequent discovery of Columbus. It is in these words:

"There will come ages, in the future years, in which the ocean may loosen the bonds of the universe and *a great land may appear* and the *sea may reveal new worlds* and there may be no *ultima thule* on earth."

## EARLY EGYPTIAN KNOWLEDGE OF THE REVOLUTION OF THE EARTH.

Miss Edwards, since the delivery of the Address, has kindly given me the authority for the statement made in her lecture referred to in the text.

Ptah, the primordial god, is said, in the great Harris Papyrus, to have "moulded man, created the gods, made the sky and formed the Earth, *revolving in space*. (Great Harris Papyrus, translated in the *Records of the Past*.)

Professor the Rev. G. Lieblein, in a paper read before the Congrès Provincial des Orientalistes at St. Etienne, and printed in the Report of its Proceedings, quotes from a hieratic inscription of the Pyramid period the following passage: "The Earth *navigates* the celestial ocean in like manner with the sun and the stars."